SECTION 3—CHEMICAL AND BIOLOGICAL SYSTEMS TECHNOLOGY

OVERVIEW

This section addresses technologies for: Bioprocessing; Chemical Manufacturing; Chemical and Biological Defense Systems; Detection, Warning and Identification; Battlefield Environment; and Human Factors. The technology areas identified in the above box contain militarily critical technologies. The other technology areas do not currently include technologies that are militarily critical. The **Chemical and Biological Defense Systems** section includes technologies that are designed to protect forces when contamination cannot be avoided and provide prophylaxis and therapy from threat agents to any affected forces. These Chemical and Biological Defense Systems technologies also cover decontamination to ensure rapid force reconstitution. **Detection, Warning and Identification** technologies covered in this section can provide real-time capability to detect, identify, locate, and quantify chemical and biological threats. Sensors must be integrated with an information processing system to analyze the threat, identify potentially affected units, and pass on alarms and warnings to implement protective measures. Both detection and protection apply to personnel operating on the ground, at sea, in the air, and in shelters and large enclosures. Although many sensor and defense technologies have commercial applications, military requirements are much more stringent. Selected toxic chemicals and biological agents which are of concern for defense and detection are presented in tabular form (see Figs. 3.0-1 and 3.0-2). Toxic chemicals are extracted from the Chemical Weapons Convention. Biological agents are extracted from the Australia Group list.

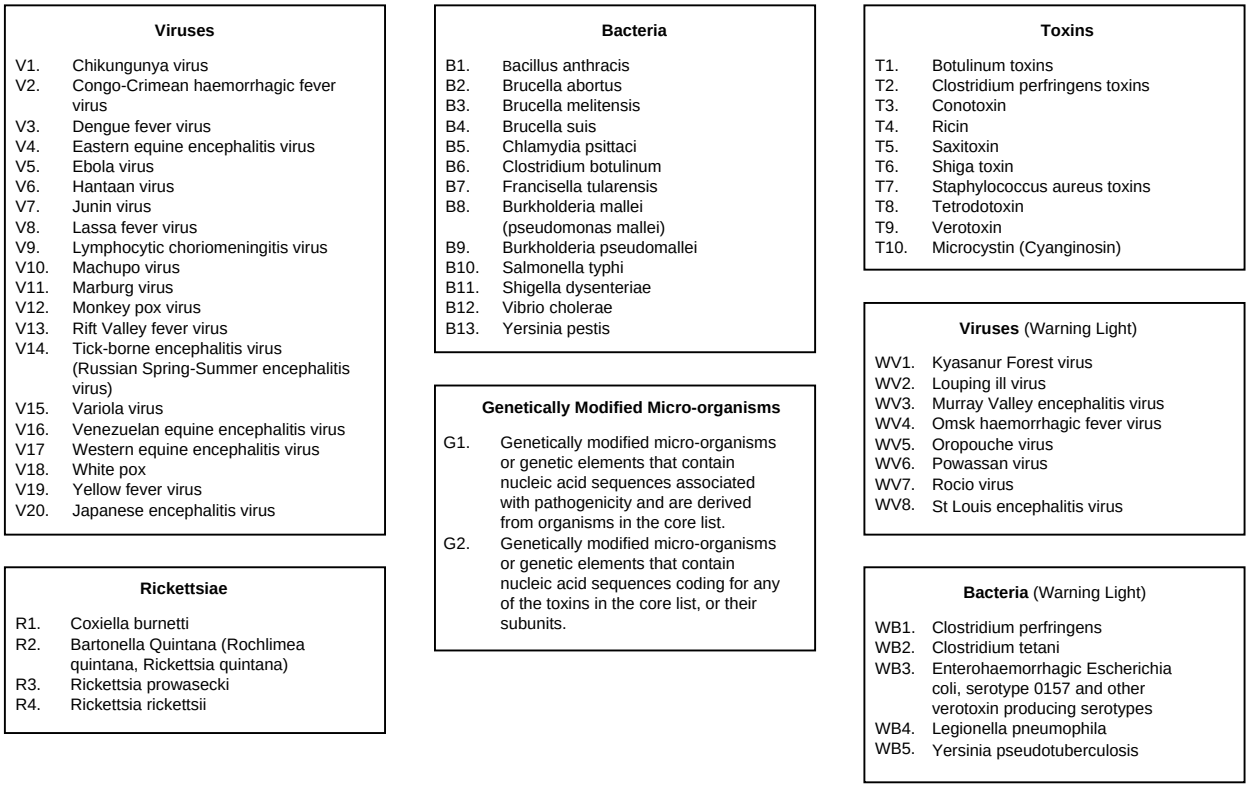

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Figure 3.0-1. Australia Group Biological/Toxin Warfare Agents

Genetically Modified Micro-organisms

G1. Genetically modified micro-organisms or genetic elements that contain nucleic acid sequences associated with pathogenicity and are derived from organisms in the warning list.
G2. Genetically modified micro-organisms or genetic elements that contain nucleic acid sequences coding for any of the toxins in the warning list, or their subunits.

Toxins (Warning Light)

WT1. Abrin
WT2. Cholera toxin
WT3. Tetanus toxin
WT4. Trichothecene mycotoxins
WT5. Modecin
WT6. Volkensin
WT7. Viscum Album Lectin 1 (Viscumin)

Animal Pathogens

Viruses:
AV1. African swine fever virus
AV2. Avian influenza virus
AV3. Bluetongue virus
AV4. Foot and mouth disease virus
AV5. Goat pox virus
AV6. Herpes virus (Aujeszky's disease)
AV7. Hog cholera virus (synonym: Swine fever virus)

(cont'd)

Animal Pathogens (cont'd)

Viruses:
AV8. Lyssa virus
AV9. Newcastle disease virus
AV10. Peste des petits ruminants virus
AV11. Porcine enterovirus type 9 (synonym: swine vesicular disease virus)
AV12. Rinderpest virus
AV13. Sheep pox virus
AV14. Teschen disease virus
AV15. Vesicular stomatitis

Bacteria:
AB3. Mycoplasma mycoides

Genetically Modified Micro-organisms
AG1. Genetically modified micro-organisms or genetic elements that contain nucleic acid sequences associated with pathogenicity and are derived from organisms in the list.

Plant Pathogens

Bacteria:
PB1. Xanthomonas albilineans
PB2. Xanthomonas campestris pv. citri

Fungi:
PF1. Colletotrichum coffeanum var. virulans (Colletotrichum Kanawae)
PF2. Cochliobolus miyabeanus (Helminthosporium oryzae)
PF3. Microcyclus ulei (syn. Dothidella ulei)
PF4. Puccinia graminis (syn. Puccinnia graminis f. sp. tritici)

(cont'd)

Plant Pathogens (cont'd)

PF5. Puccinia striiformis (syn. Pucciniaglumarum)
PF6. Pyricularia grisea/Pyricularia oryzae

Genetically Modified Micro-organisms
PG1. Genetically modified micro-organisms or genetic elements that contain nucleic acid sequences associated with pathogenicity derived from the plant pathogens on the list.

Awareness Raising Guidelines

Bacteria:
PWB1. Xanthomonas campestris pv. oryzae
PWB2. Xylella fastidiosa

Fungi:
PWF1. Deuterophoma tracheiphila (syn. Phoma tracheiphila)
PWF2. Monilia rorei (syn. Moniliophthora rorei)

Viruses:
PWV1. Banana bunchy top virus

Genetically Modified Micro-organisms
PWG1. Genetically modified micro-organisms or genetic elements that contain nucleic acid sequences associated with pathogenicity derived from the plant pathogens identified on the awareness raising list.

Figure 3.0-1. Australia Group Biological/Toxin Warfare Agents (Continued)

Nerve Agents	(C.A.S. Number)**
O-Alkyl ($\leq C_{10}$, incl. cycloalkyl) alkyl	
(Me, Et, n-Pr or i-Pr)-phosphonofluoridates	(107-44-8)
e.g. Sarin: O-Isopropyl methylphosphonofluoridate	(96-64-0)
Soman: O-Pinacolyl methylphosphonofluoridate	
O-Alkyl ($\leq C_{10}$, incl. cycloalkyl) N,N-dialkyl	
(Me, Et, n-Pr or i-Pr) phosphoramidocyanidates	
e.g. Tabun: O-Ethyl N,N-dimethyl phosphoramidocyanidate	(77-81-6)
O-Alkyl (H or $\leq C_{10}$, incl. cycloalkyl) S-2-dialkyl	
(Me, Et, n-Pr or i-Pr)-aminoethyl alkyl	
(Me, Et, n-Pr or i-Pr) phosphonothiolates and corresponding alkylated or protonated salts	
e.g. VX: O-Ethyl S-2-diisopropylaminoethyl methyl phosphonothiolate	(50782-69-9)
Vesicants	
Sulfur mustards:	
2-Chloroethylchloromethylsulfide	(2625-76-5)
Mustard gas: Bis(2-chloroethyl)sulfide	(505-60-2)
Bis(2-chloroethylthio)methane	(63869-13-6)
Sesquimustard: 1,2-Bis(2-chloroethylthio)ethane	(3563-36-8)
1,3-Bis(2-chloroethylthio)-n-propane	(63905-10-2)
1,4-Bis(2-chloroethylthio)-n-butane	(142868-93-7)
1,5-Bis(2-chloroethylthio)-n-pentane	(142868-94-8)
Bis(2-chloroethylthiomethyl(ether)	(63918-90-1)
O-Mustard: Bis(2-chloroethylthioethyl)ether	(63918-89-8)

Vesicants (cont'd)	
Lewisites:	
Lewisite 1: 2-Chlorovinyldichloroarsine	(541-25-3)
Lewisite 2: Bis(2-chlorovinyl)chloroarsine	(40334-69-8)
Lewisite 3: Tris(2-chlorovinyl)arsine	(40334-70-1)
Nitrogen mustards:	
Lewisite 1: 2-Chlorovinyldichloroarsine	(538-07-8)
Lewisite 2: Bis(2-chlorovinyl)chloroarsine	(51-75-2)
Lewisite 3: Tris(2-chlorovinyl)arsine	(555-77-1)
Toxins	
Saxitoxin	(35523-89-8)
Ricin	(0990-86-3)
Choking Agent	
Phosgene: Carbonyl dichloride	(75-44-5)
Blood Agents	
Cyanogen chloride	(506-77-4)
Hydrogen cyanide	(74-90-8)

* This list is representative and not all inclusive.
** The C.A.S. number is the Chemical Abstract Service Registry Number, a unique number based on chemical structure.

Figure 3.0-2. Selected Toxic Chemicals Requiring Detection, Warning, Identification, and Defense*

SECTION 3.1—CHEMICAL AND BIOLOGICAL DEFENSE SYSTEMS

OVERVIEW

The U.S. chemical and biological defense program includes contamination avoidance, individual and collective protection, and decontamination, all of which are addressed in this section. Contamination avoidance is based on sensors providing real-time detection and identification of toxic agents (see Section 3.2). The goal of individual and collective protection is to insulate U.S. ground, air, and sea forces from CB agents using clothing ensembles and respirators for individuals and collective filtration systems for groups. Additional precautions can be taken for biological agents such as immunization prior to exposure and antidote treatments after exposure provided the threat agents can be identified. Military requirements for individual protection are much more stringent than those used in commercial applications. Manufacturers deal with known processes, inputs, and outputs. The military must be prepared to respond to unknown threats including new agents in unknown quantities anywhere, and at any time. Since many types of protective gear limit human performance, sometimes up to a 50-percent reduction in capabilities, more advanced efforts are aimed at accounting for these limitations and increasing the comfort/wear time and freedom of action. Decontamination technologies that ensure rapid and effective force reconstitution are also included. Modeling and simulation are used for hazard assessment, weapons effects, and the results of decontamination.

Table 3.1-1. Chemical and Biological Defense Systems Militarily Critical Technology Parameters

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
PRODUCTION AND DESIGN TECHNOLOGY FOR PROTECTIVE MASKS - BIOLOGICAL	Provide protection against aerosol particles in the 0.1 to 10 micrometer range	Butyl rubber, silicon rubber; plastics	Simulated agents; leakage testers; mannequin - face model for mask and suit design; particle-size analysis equipment	Software for generating facial contours	WA ML 7
PRODUCTION AND DESIGN TECHNOLOGY FOR PROTECTIVE MASKS - CHEMICAL	Provide protection for 24 hrs against 10,000 mg-min/m^3 challenge for toxic vapors, aerosols	Butyl rubber Silicone rubber plastics	Simulated agents; Leakage testers; mannequin-face model for mask and suit design; particle-size analysis equipment	Software for generating facial contours	WA ML 7
PRODUCTION AND DESIGN TECHNOLOGY FOR PROTECTIVE CLOTHING - CHEMICAL	Provide protection for 24 hrs against 10 g/m^2 challenge by all liquid agents and 10,000 mg-min/m^3 for toxic vapors, aerosols	Impregnated activated carbon (charcoal); Charcoal activated cloth; semi-permeable mem-branes; polymers	Simulated agents; particle-size analysis equipment	None identified	WA ML 7
PRODUCTION AND DESIGN TECHNOLOGY FOR COLLECTIVE PROTECTION - BIOLOGICAL	Provide protection against aerosol particles in the 0.1 to 10 micrometer range	Teflon/Kevlar laminate for biological resistance, decontaminability and environmental durability	Simulated agents	None identified	WA ML 7

(Continued)

Table 3.1-1. Chemical and Biological Defense Systems Militarily Critical Technology Parameters (Continued)

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
PRODUCTION AND DESIGN TECHNOLOGY FOR COLLECTIVE PROTECTION - CHEMICAL	Prevent > 99.9% of toxic agents from entering common areas	Impregnated carbon filters; polyethylene; fluoropolymer/aramid laminate	Simulated agents	None identified	WA ML 7
DECONTAMINATION - BIOLOGICAL	Sieve or remove 0.1 to 10 micrometer particles	Filter system to remove 0.1 to 10 micrometer particles by sieve action	Simulated agents	None identified	WA ML 7
DECONTAMINATION - CHEMICAL	Remove > 99.9% of toxic material or neutralize it	AMBERGARD XE-555 resin; sodium hydroxide); Super-Tropical Bleach (STB)	Simulated agents	None identified	WA ML 7

SECTION 3.2—DETECTION, WARNING, AND IDENTIFICATION

OVERVIEW

Technologies used for detection, warning, and identification of toxic chemical and biological agents are included in this section. Detectors used at designated locations are called point detectors. Standoff detectors provide early, wide area warning of an attack. Detection technologies must be capable of sensing and mapping large areas of non-volatile liquid chemical agent contamination and to be able to rapidly discriminate and identify biological agents. For biological agents, detection and warning systems are based on physical or chemical properties of these agents. Identification systems use immunochemical or gene probe techniques or mass spectral analysis. No single sensor detects all chemical or biological agents of interest. Detectors for toxic agents must have a short response time with a low rate of false returns and meet appropriate size, weight, and power requirements. Detection equipment must be integrated with a command and control system to ensure an alarm is disseminated. This is essential for contamination avoidance. Other unknown factors include location, duration, and intensity of the agent, which are crucial parameters for command decisions. Current DoD emphasis is on multiagent sensors for biological detection and standoff CB detection. The technology focus is on detection, warning and identification across the spectrum of CB agents as well as on the integration of CB detectors into various platforms, individual clothing and the C^3I network. Identification is critical to medical response.

Table 3.2-1. Detection, Warning, and Identification Militarily Critical Technology Parameters

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
IMMUNO BASED - BIOLOGICAL	Capability of detecting 100 organisms of Australia Group agents.	Antibodies directed against Australia Group list agents	Antibody development	None identified	WA ML 7 WA IL Cat 1 AG
GENE BASED PROBE - BIOLOGICAL	Capability of detecting 100 organisms of Australia Group agents.	Polynucleolides complementary to Australia Group gene sequences; polymers	Gene sequence data	None identified	WA ML 7 WA IL Cat 1 AG
MOLECULAR RECOGNITION (E.G. ANTIGENS, ANTIBODIES, ENZYMES, NUCLEIC ACIDS, OLIGOMERS, LECTINS, WHOLE CELLS, RECEPTORS, ORGANELLES) - BIOLOGICAL	Capability of detecting 100 organisms of Australia Group agents. Can recognize weapons grade agent, by-products of its preparation or manufacturing signatures; does not recognize normally occurring environmental materials.	Antibodies directed against Australia Group list agents or polynucleotides complementary to Australia Group gene sequence	Coatings, films or fibers of biopolymers or chemical polymers that bind BW agents (binding K_d less than 1×10^{-8})	Molecular modeling databases (e.g. protein and DNA sequencing)	WA ML 7 WA IL Cat 1 AG
ION MOBILITY SPECTROMETRY (IMS) - BIOLOGICAL	Detecting several thousand organisms.	None identified	Database development; Ion source Spectroscope capable of concentrating and analyzing 1000 organisms	Spectrum recognition algorithms	WA ML 7 WA IL Cat 1 AG
ION MOBILITY SPECTROMETRY (IMS) - CHEMICAL	Capable of scanning samples of 10,000 daltons or less in 5 minutes or less.	None identified	Database development; Ion source	Spectrum recognition algorithms	WA ML 7 WA IL Cat 1 AG

(Continued)

Table 3.2-1. Detection, Warning, and Identification Militarily Critical Technology Parameters (Continued)

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
MASS SPECTROMETRY - BIOLOGICAL	Capable of scanning samples of 10,000 daltons or less in 5 minutes or less.	None identified	Database development Portable, field rugged mass spectroscope	Spectrum recognition algorithms	WA ML 7 WA IL Cat 1 AG
MASS SPECTROMETRY - CHEMICAL	Capable of scanning samples of 10,000 daltons or less in 5 minutes or less.	None identified	Database development	Spectrum recognition algorithms	WA ML 7 WA IL Cat 1 AG
PASSIVE IR - CHEMICAL	Detects vapors at distances up to 5 km (Nerve: 90 mg/m^2, blister: 500 mg/m^2 for L and 1500 mg/m^2 for HD).	None identified	Database development	Spectrum and background recognition algorithms	WA ML 7 WA IL Cat 1 AG
TRANSDUCERS (E.G., OPTICAL, ELECTROCHEMICAL, ACOUSTIC, PIEZOELECTRIC, CALORIMETRIC, SURFACE ACOUSTIC WAVE (SAW); FIBER OPTIC WAVE GUIDE) - BIOLOGICAL, CHEMICAL	Converts recognition of agents to an optical or electrical signal. Low hysteresis. Optical/electronic component processing must be <1 second.	Antibodies and gene sequences for Australia Group list agents	Production equipment configured for the detection of biological agents	Spectrum recognition algorithms	WA ML 7 WA IL Cat 1 AG
SAMPLE COLLECTION (E.G. AIR, LIQUID, DUST, SOIL SAMPLING) - BIOLOGICAL	Collects and concentrates 1–10 micrometers particles into liquid medium.	None identified	Aerosol samplers able to collect less than or equal to 10 micrometers diameter particles into a liquid	None identified	WA ML 7 WA IL Cat 1 AG
SAMPLE COLLECTION (E.G. AIR, LIQUID, DUST, SOIL SAMPLING) - CHEMICAL	Collects and concentrates 1–10 micrometers particles into liquid medium.	None identified	Aerosol samplers able to collect less than or equal to 10 micrometers diameter particles into a liquid.	None identified	WA ML 7 WA IL Cat 1 AG
SAMPLE PROCESSING (E.G. CELL DISRUPTION, CONCENTRATION, PURIFICATION OR STABILIZATION) - BIOLOGICAL	Completion within 10 minutes.	None identified	Neg. pressure orifice devices for rupturing cell membranes or wall/retention of nucleic acids; impact collectors; ion trap mass spectrometers capable of scanning samples below 10,000 daltons in 5 minutes or less; pyrolyzers.	Spectrum recognition algorithm	WA ML 7 WA IL Cat 1 AG
SAMPLE PROCESSING (E.G. CONCENTRATION) - CHEMICAL	Completion within 10 minutes.	None identified	Ion trap mass spectrometers capable of scanning samples from 40 to 1024 daltons in milli-secs; pyrolyzers; chemical and enzyme detection kits.	Spectrum recognition algorithm	WA ML 7 WA IL Cat 1 AG